COMMON ELAND

Tragelaphus oryx

ABUNDANCE ESTIMATES

Nkhotakota Wildlife Reserve | 2018–2020

USAID
FROM THE AMERICAN PEOPLE

FOREST SERVICE
DEPARTMENT OF AGRICULTURE

COMMON ELAND ABUNDANCE ESTIMATES

NKHOTAKOTA WILDLIFE RESERVE

US Department of Agriculture Forest Service
Pacific Northwest Research Station
International Programs
&
Oregon State University
Department of Fisheries, Wildlife, and Conservation
Department of Forest Ecosystems and Society

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RESEARCH TEAM

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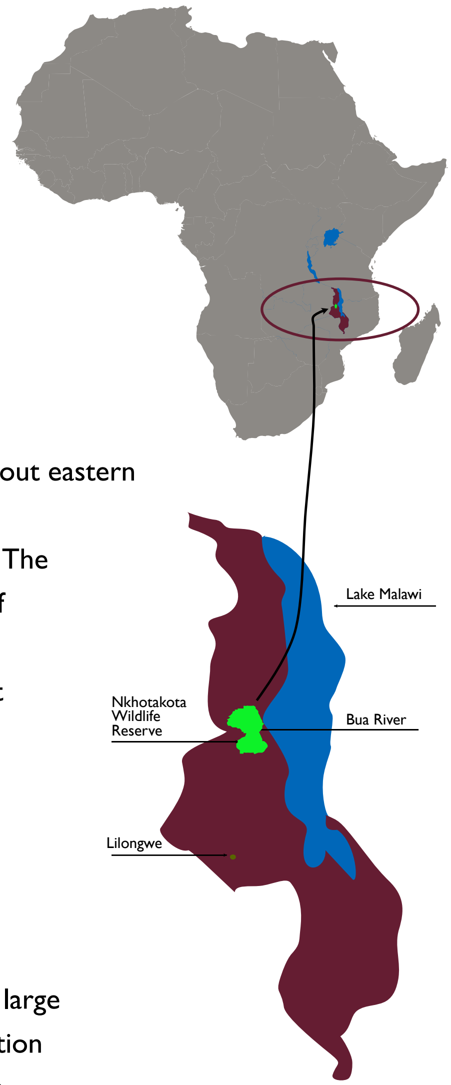
The camera trap used in this analysis: a Bushnell Trophy Cam HD Aggressor No-Glow Trail Camera, made in Overland Park, Kansas, USA.
Photo credit: John Kerkering

ACRONYMS

ACRONYM	DEFINITION
APM	Africa Parks Malawi
NWR	Nkhotakota Wildlife Reserve
REM	Random Encounter Model
USAID	United States Agency for International Development
USDA	United States Department of Agriculture
USFS	United States Forest Service

Nkhotakota Wildlife Reserve specialists attach a camera trap.
Photo credit: John Kerkering

1.0 INTRODUCTION



As part of its mission to restore ecological function and encourage wildlife tourism of Nkhotakota Wildlife Reserve (NWR; ~1,800 km^2), African Parks Malawi (APM) translocated 25 common eland (Tragelaphus oryx, hereafter eland) to NWR in 2016 from other protected areas in Malawi. Translocated animals were initially confined to a 190 km^2 sanctuary within NWR and after completion of the second stage of perimeter fencing in 2017 were given access to a larger area of 780 km^2 (Figure 1).

Eland are distributed in woodland and wooded savanna throughout eastern and southern Africa (Kingdon 1997) and are classified as Least Concern by the IUCN (IUCN Antelope Specialist Group 2016). The total population was estimated in 1999 at 136,000 individuals, of which approximately 50% are found in protected areas (IUCN Antelope Specialist Group 2016). The eland is among the largest antelope (males: 400–942 kg; females: 300–600 kg) and are considered potentially attractive to illegal hunters due to their large size and the high quality of their meat (Kingdon 1997).

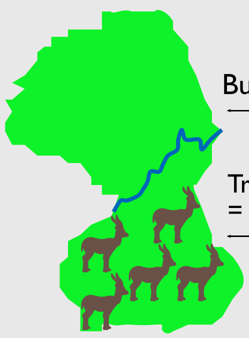
Malawi is cited as one of the countries with a stable or increasing population of this species (IUCN Antelope Specialist Group 2016). Despite their large body size and like many other large mammals, eland can be difficult to monitor and estimate population abundance with many survey methods because of low detection probability in dense vegetation (Caro 2011).

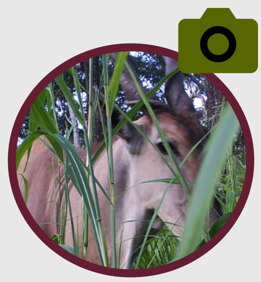
NKHOTAKOTA WILDLIFE RESERVE

Total area = 180,000ha
Or 1,800km^2 / 694 mi^2

2016

25 common eland transferred to NWR





NOV. 2018 - AUG 2020

99 eland photographs captured from 9 hexagons* with 11 camera stations

Using the random encounter model and number of eland photos captured in a 780km^2 area, eland abundance was estimated at 32 (CI = 20–48). These estimates are slightly lower than the expected population size of 62 based on the initial population of 25, three years of growth, and an expected annual population growth rate of approximately 0.36.

*Hexagon = 5km^2, with three camera traps spaced 1.4km^2 apart.

Empirical data on eland population abundance are lacking for NWR, so Lesmeister et al. (2019) used best available information from the literature to develop an eland population growth model. These previous efforts can be informative for management plans because vital rates and population dynamics for eland in NWR should be correlated with population dynamics in other locations. However, long-term population monitoring data specific to NWR are critical because annual fluctuations in population growth caused by variation in environmental stochasticity, age-specific survival, reproductive rates, calving frequency, recovering predator populations, poaching pressure, as well as other factors affect population performance and are likely to differ relative to other studies. Recognizing the importance of site-specific empirical data to inform wildlife management, APM partnered with USDA Forest Service with support from U.S. Agency for International Development (USAID) to establish a camera-based wildlife monitoring program at NWR (Lesmeister et al. 2020). The wildlife monitoring program was designed to be appropriate for a wide range of species that are key indicators for monitoring forest biodiversity. Eland were a focal species and central to the monitoring design given their management importance. Here we present initial findings on estimates of eland abundance in 2020 generated by the monitoring program.

2.0 STUDY AREA

Vegetation within NWR (~1,800 km^2) is dominated by open-canopy *Brachystegia* miombo woodlands and is exemplar of intact miombo woodland. Annual rainfall for NWR averages 1,190 mm, with a wet season spanning roughly November to April that supplies > 97% of annual precipitation. Monthly average temperatures range from 18°C in July to 25°C in November. The Bua River runs through the reserve and constitutes a major perennial source of surface water. Since taking over management of the reserve in 2015, APM has made it a goal to complete a perimeter fence and dramatically increase law enforcement personnel and patrol coverage, which is expected to significantly curtail poaching activity (Kurland et al. 2017).

Sunset on the Bua River. Photo credit: USDA Forest Service

3.0 METHODS

We estimated eland abundance using the random encounter model (REM; Rowcliffe et al. 2008). The REM model assumes that animals or groups of animals moving across the landscape will encounter camera trap sites at rates relative to their density, similar to the rates of collision among gas molecules (Hutchinson and Waser 2007). The REM estimates density as a function of photo capture rate, animal movement velocity, and the area of the camera trap detection zone given by:

$$D = \frac{C}{t}\frac{\pi}{vr(2+\theta)}$$

C is the number of photos recorded during time interval *t*, v is the animal movement rate, *r* is the camera detection radius, and θ is the interior angle of the camera trap detection zone. The manufacturer's specifications for our camera traps were defined as θ = 0.785398 radians. We used the parametric formulation of the REM moments estimator (Jourdain et al. 2020), which assumes the counts at each site *i* follow a Poisson distribution given by:

$$C_i \sim Poisson(\lambda_i)$$
$$\lambda_i = \frac{(2+\theta)rt}{\pi}vD$$
$$D \sim Uniform(0\,m, 10\,m),$$

where *D* is the density of eland groups. We used informative priors to estimate both *v* and *r*, because we lacked telemetry data for eland on our sites and because previous analyses found that the realized camera detecting radius on our sites was less than the manufacturers specifications (18.28 m) (Lesmeister et al. 2021). Our estimate of *v* was assumed to follow a truncated normal distribution with a mean of 58.8 km / week and a standard deviation of 5 km / week, this distribution was truncated to a minimum (38.8 km) and maximum (78.8 km) weekly movement rates. Our informative prior for weekly movement rate was inferred based on the daily movement rates of eland in woodlands of the Serengeti National Park, Tanzania (Palmer et al. 2018). Our estimate of *r* was informed by posterior distribution for camera detection radius reported by Lesmeister et al. (2021) for African elephant (*Loxodonta africana*) population estimates from the same camera trap deployment.

We derived abundance as a function of eland group density, the fenced reserve area (780 km^2), and average group size given by:

$$N = D * 780km^2 * G$$

Average group size estimated using the full dataset was G = 1.79 eland; however, after initial data exploration we found an excess of individuals traveling alone, which were most likely young males. Thus, we removed individual detections and estimated group size using the remainder of eland group detections and estimated group size G = 2.83. The models were fit using JAGS software version 4.3.0 (Plummer 2003) using the R2jags package version 0.6-1 (Su and Yajima 2020) in R version 4.0.2 (R Core Team 2020). The model was fit using three independent Markov chains consisting of 5,000 iterations following a 5,000 iteration burn in period. We assessed model convergence by visual examination of trace plots and we computed the Brooks–Gelman–Rubin convergence diagnostic ($\hat{R}$) (Brooks and Gelman 1998). Convergence ($\hat{R}$ <1.1) was obtained for all monitored parameter estimates. We describe parameter posterior distributions by their mean and 95% credible interval (hereafter CI).

4.0 RESULTS

To estimate eland abundance, we used photographic data collect from within the 780-km^2 fenced area (29 hexagons, 88 camera stations) during November 2018 to August 2020. Cameras were operational for an average of 49 weeks (range = 6–93 weeks). We obtained 99 photographs of eland from 9 hexagons and 11 camera stations. We estimated weekly eland movement rates were 58.74 km per week (CI = 54.91–62.64). We estimated eland abundance was 32 (CI = 20–48) during the sampling period in the 780-km^2 fenced portion of NWR. These estimates are slightly lower than the expected population size of 62 based on the initial population of 25, three years of growth, and an expected annual population growth rate of approximately 0.36 reported elsewhere (Jolles 2007, Dublin and Ogutu 2015). But our estimates are consistent with an expected abundance ranging 40–52 based on an assumed population dynamic system based on the following assumptions: 1) 25 eland were translocated into Nkhotakota Wildlife Reserve and there was no extant population, 2) the translocated eland did not reproduce during the first year following translocation (Brandlová and Hejcmanová 2022), 3) there are no predators of eland in the fenced preserve (i.e., lion Panthera leo), 4) adult survival is nearly 100 % and juvenile survival is ~90 % (Brandlová and Hejcmanová 2022).

5. DISCUSSION

Here we present eland abundance estimates derived from non-invasive camera-trap data and REMs not requiring identification of individual eland. Coupled with population growth models (Lesmeister et al. 2019), these methods can be effective tools to understand population conditions and for developing a set of scenarios for management planning. Our mean estimate of 32 (CI = 20–48) individuals suggests annual population growth has been positive and indicates success of the ecological restoration program at NWR after translocations. Our estimated densities of eland (0.04/km^2) are lower than estimates of 0.19/km^2 found in other miombo woodland reserves (Waltert et al. 2009), so we can expect continued positive population growth as the species continues to establish within NWR.

In the long term, the availability of forage may become the most important factor limiting eland population growth in NWR. Intra- and interspecific competition for food resources will likely have the strongest effects on age of first reproduction and juvenile survival, followed by subadult survival and inter-birth intervals among mature females (Gaillard et al. 2000). In Kruger National Park, South Africa, adult eland survival was high and relatively stable from year to year, although severe drought events resulted in periodic high rates of mortality (Owen-Smith et al. 2012). However, rainfall is higher and less variable in NWR, so in the short and mid-term, the eland population's growth will likely follow that of reintroduced populations in similar areas, such as Majete Wildlife Reserve in southern Malawi. After a near-total extirpation of large herbivores by the 1990s, populations of several herbivore species were reestablished between 2003 and 2010 and appear to have grown rapidly in the years since. Although peer-reviewed estimates of the population growth of the Majete eland are not available, it seems reasonable to expect qualitatively similar behavior in the NWR population in the near term given the similar circumstances (i.e., reintroduced population to a protected reserve) initially at low density, subject to minimal pressure from hunting or predation.

Efforts to monitor the eland population in NWR have been dramatically strengthened by the availability of photographic data from the network of camera traps deployed by APM staff. Eland are not amenable to individual identification or direct aging from photographs alone, but the REMs we used have proven effective to estimate abundance without these data. The REM model assumption that animals or groups of animals moving across the landscape will encounter camera trap sites at rates relative to their density could be violated if movements are confined to localized areas or vegetation types. However, given the dominance of miombo woodland mixed with grassland at NWR, REMs appear to be effective for eland. Movement rates estimated from tracking data collected at NWR will likely enhance suitability and effectiveness of these model estimates. Further, in future analyses, it may be effective to include habitat covariates to the model to account for variable distribution due to habitat (Jourdain et al. 2020).

Miombo Woodland, Nkhotakota Wildlife Reserve. Photo credit: USDA Forest Service.

6.0 ACKNOWLEDGMENTS

Funding to support this work was provided by US Agency for International Development in Malawi, USDA Forest Service International Programs, and USDA Forest Service Pacific Northwest Research Station. We are deeply indebted to the staff of African Parks Malawi for establishing and maintaining the monitoring program to generate knowledge most relevant to meet their management goals.

7.0 LITERATURE CITED

Brandlová, K., and P. Hejcmanová. 2022. Individual-based assessment of post-translocation fitness of ungulates: Lessons from the critically endangered Derby eland conservation programme. Conservation Science and Practice 4:e12837.

Brooks, S. P., and A. Gelman. 1998. General methods for monitoring convergence of iterative simulations. Journal of Computational and Graphical Statistics 7:434–455.

Caro, T. 2011. On the merits and feasibility of wildlife monitoring for conservation: a case study from Katavi National Park, Tanzania. African Journal of Ecology 49:320-331.

Dublin, H. T., and J. O. Ogutu. 2015. Population regulation of African buffalo in the Mara–Serengeti ecosystem. Wildlife Research 42:382-393.

Gaillard, J. M., M. Festa Bianchet, N. G. Yoccoz, A. Loison, and C. Toigo. 2000. Temporal variation in fitness components and population dynamics of large herbivores. Annual Review of Ecology and Systematics 31:367-393.

Hutchinson, J., and P. M. Waser. 2007. Use, misuse and extensions of "ideal gas" models of animal encounter. Biological Reviews 82:335–359.

IUCN Antelope Specialist Group. 2016. Tragelaphus oryx. The IUCN Red List of Threatened Species 2016 2016:e.T22055A115166135.

Jolles, A. E. 2007. Population biology of African buffalo (Syncerus caffer) at Hluhluwe-iMfolozi Park, South Africa. African Journal of Ecology 45:398-406.

Jourdain, N. A. O. S., D. J. Cole, M. S. Ridout, and J. M. Rowcliffe. 2020. Statistical development of animal density estimation using random encounter modelling. Journal of Agricultural, Biological, and Environmental Statistics 25:148-167.

Kingdon, J. 1997. The Kingdon Field Guide to African Mammals Academic Press, San Diego, CA.

Kurland, J., S. F. Pires, S. C. McFann, and W. D. Moreto. 2017. Wildlife crime: a conceptual integration, literature review, and methodological critique. Crime Science 6:4.

Lesmeister, D. B., C. L. Appel, and A. Chibwana. 2020. Ecological Monitoring of Nkhotakota Wildlife Reserve: USFS Technical Mission Report (Session IV, December 2019). Unitied States Agency for International Development: USDA Forest Service, International Programs.

Lesmeister, D. B., C. L. Appel, M. J. Weldy, A. Chibwana, and J. Kerkering. 2021. African Elephant (Loxodonta africana) Abundance Estimates for Nkhotakota Wildlife Reserve. USDA Forest Service Pacific Northwest Research Station and International Programs.

Lesmeister, D. B., Z. J. Ruff, and J. Kerkering. 2019. Eland Population Growth Model for Nkhotakota Wildlife Reserve, Malawi USDA Forest Service, Pacific Northwest Research Station and International Programs.

Owen-Smith, N., G. J. Chirima, V. Macandza, and E. Le Roux. 2012. Shrinking sable antelope numbers in Kruger National Park: what is suppressing population recovery? Animal Conservation 15:195-204.

Palmer, M. S., A. Swanson, M. Kosmala, T. Arnold, and C. Packer. 2018. Evaluating relative abudance indices for terrestrial herbivores from large-scale camera trap surveys. African Journal of Ecology 56:791-803.

Plummer, M. 2003. JAGS: A program for analysis of Bayesian graphical models using Gibbs sampling. Proceedings of the 3rd international workshop on distributed statistical computing 124:1-8.

R Core Team. 2020. Version 4.0.2. R Foundation for Statistical Computing, Vienna, Austria.

Rowcliffe, J. M., J. Field, S. T. Turvey, and C. Carbone. 2008. Estimating animal density using camera traps without the need for individual recognition. Journal of Applied Ecology 45:1228-1236.

Su, Y.-S., and M. Yajima. 2020. Package 'R2jags' version 0.6-1. in.

Waltert, M., B. Meyer, and C. Kiffner. 2009. Habitat availability, hunting or poaching: what affects distribution and density of large mammals in western Tanzanian woodlands? African Journal of Ecology 47:737-746.

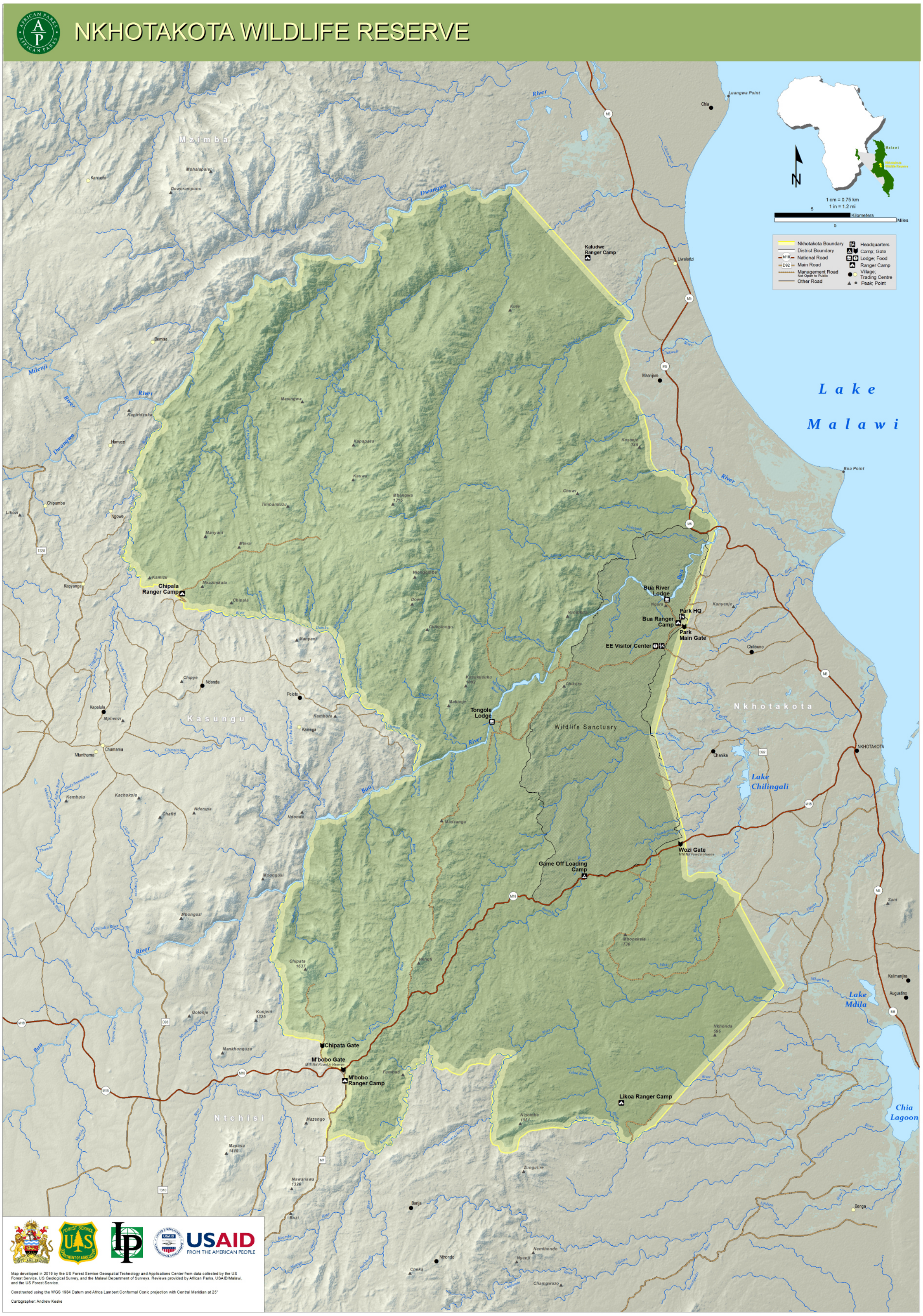


Figure 1. Nkhotakota Wildlife Reserve, in green, ca. 180,000 ha.

An eland pops into view of the camera trap, lower right. Despite their large body size, elands can be difficult to monitor and estimate population abundance because of low detection rate among dense vegetation.

Bushnell camera trap 07/21/2019 NWR

Bushnell camera trap 07/21/2019 NWR

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